AMENDMENTS TO THE SPECIFICATION

In the specification, please delete the paragraph at page 2, line 12 through page 3, line 11 and substitute therefor the following substitute paragraph:

--The present invention provides a welding process with consistent lower hydrogen weld deposits, higher electrode efficiencies and improved operating features compared to the previous flux cored welding procedure. The invention is used with a gas shielding and preferably employs solid metal wire. This wire provides reduced hydrogen in weld deposits, but was not the wire of choice in the prior process. The pulse welding process of the invention has an improved procedure for addressing short circuits that occur randomly. In this manner, solid wire with gas shielding can be used in electric arc pulse welding to overcome the disadvantages of previous processes using flux cored electrodes. The present invention relates to a pulse spray process to transfer metal, which process uses a novel procedure and method of removing inadvertent, randomly occurring short circuits between an electrode and workpiece. By using the present invention, the hydrogen is reduced in the metal deposit tending to eliminate the occurrence of hydrogen assisted cracking. Although the invention is described and has been developed for a single solid wire electrode, the new process is also suitable for use in multiple arc processes using tandem electrodes each driven by a high speed switching power source, such as an inverter or chopper. The power source or sources each output a succession of pulse waveforms created by a pulse waveform generator or wave shaper. The invention is optimized when using a Super Arc LA-75 solid wire electrode and shielding gas in combination in order to meet or exceed Charpy impact values of 35 ft-lbs at -40°F. The process developed in accordance with the present invention is useful in all welding positions and is referred to by the acronym GMAW-P ~~GMAW-P.~~. The process of the present invention lowers diffusible hydrogen and reduces or eliminates the holding time requirement for completed weldment prior to non-destructive examination.--

In the specification, please delete the paragraph at page 3, lines 12-21, and substitute therefor the following substitute paragraph:

--The invention uses a standard power source that can provide waveform technology, such as a Power Wave 455 manufactured and sold by The Lincoln Electric

Company of Cleveland, Ohio, a pioneer in waveform technology. Waveform technology is a shorthand for a welding process using a high switching speed power source, such as an inverter or chopper with waveforms created in succession. Each waveform~~waveforms~~ has a profile determined by the program of the waveform generator or wave shaper having an output signal controlling the operation, on a time basis, of a pulse width modulator of the power source controller. The pulse width modulator operates at a frequency greater than 18-20 kHz. The ability to use a pulsed spray welding process with a solid metal wire or electrode is enhanced and made possible by using the present invention.--

In the specification, please delete the paragraph at page 8, line 2 through page 10, line 2 and substitute therefor the following substitute paragraph:

--The pulsed spray weld process improved by use of the present invention employs a standard electric arc welder, such as welder A show in FIGURE 1 wherein power source 10 is a high switching speed power source, such as an inverter or chopper, with an input power supply 12 illustrated as a three phase electrical input. Of course, a single phase input power supply having various voltages and frequencies or even a motor or engine driven generator or alternator could be used to direct electrical power to converter or power source 10. Output leads 14, 16 are connected in series across electrode E and workpiece WP to perform a welding process by directing current between the electrode and workpiece. In accordance with standard practice, the electrode is a continuous wire which in the prior art was a flux cored wire, but in the present invention~~invention is~~ a solid wire can be used. This was not possible in some off-shore applications before use of the present invention. By using solid wire the hydrogen in the weld bead is reduced to reduce hydrogen assisted cracking. In accordance with the preferred embodiment of the invention, the solid wire has a shielding gas formed of 95% argon and 5% carbon dioxide. The shielding gas supply is directed into the welding operation between the electrode and workpiece in accordance with standard practice. The invention allows use of solid wire to replace cored wire heretofore required when using pulsed spray welding. Wire 20 is pulled from spool 22 between drive rolls 24, 26 rotated by motor 30 in accordance with standard technology. Contact sleeve 40 is used to direct electrical current from power source 10 to electrode E so that the welding process performed between the electrode and workpiece

comprises the current waveforms between outputs 14, 16. To determine the arc current, shunt 50 creates a signal in line 52 directed to feedback circuit 54 so that the output signal on line 56 is a digital or analog representation of the actual output current at any given time. In a like manner, voltage feedback circuit 60 has inputs 62, 64 for sensing the instantaneous arc voltage of the welding operation to create a signal in output 66. This voltage signal is a digital or analog representation of the instantaneous arc voltage. The arc current and voltage are directed in a feedback loop to waveform generator 70 which generator is set to create a series of waveforms each with a selected profile, in accordance with a signal in control line 72. The control signal represents the desired pulse waveform. Output control signal in line 72 is either in the form of digital instructions, a program statement or an analog command signal in accordance with standard waveform technology. Inside the controller of the power source is a pulse width modulator circuit, normally a software signal, which circuit controls the waveforms in the welding process between electrode E and workpiece WP. This is a waveform to create a pulsed spray welding process. A standard waveform created by the signal in line 72 from generator 70 is schematically illustrated in FIGURE 4. Waveform B has a standard profile from a start position a at time T0. To create the pulse profile, a current ramp up portion b is created by generator 70 until the lapsed time T1. Thereafter, waveform B progresses into a current peak portion c that lasts until lapsed time T2. After the peak current portion is performed, waveform B shifts into a current down ramp d terminating at time T3 where the waveform is shifted to the background current portion e. This portion terminates at lapsed time T4 corresponding with waveform start time T0. The invention is preferably performed in a waveform technology welder with a waveform B. However, other welders can use the invention and the waveform but such other welders may not have the ramp up portion or a ramp down portion. The invention can still be used effectively to allow use of solid wire when such wire was not practical so a FCAW was necessary.--

In the specification, please delete the paragraph at page 10, line 3 through page 12, line 18 and substitute therefor the following substitute paragraph:

--Standard waveform technology preferably used in the invention repeatedly outputs waveform B under control of generator 70 to produce a pulsed spray welding process. The waveform generator is a processor that synthesizes a waveform based

upon a series of instructions and true/false statements. The waveform generator regulates the instructions from the current feedback signal 56. When this signal is correct, the generator then processes the signal on line 66 so that both a current and a voltage waveform is controlled by generator 70. Voltage and current signals are fed back to waveform generator 70 by lines 56, 66 to correct the output control signal 72 in order to correct the signal and produce the desired waveform between electrode E and workpiece WP. This process is implemented by various methods that are well known in the art of using waveform technology to control successive pulse waveforms. The waveform technology process can be optimized by proper selection of parameters defining the profile of waveform B. However, when there is an inadvertent, unexpected, unplanned short circuit between the electrode and workpiece, the quality of the weld created by waveform B is adversely affected. Less energy is directed to the welding process because the resistance experienced by the power source is drastically reduced. Consequently, it is necessary to immediately address a short circuit condition to again reestablish the optimized waveforms necessary for quality performance of the welding operation. In the prior art, waveform technology or other pulsed spray waveform processes form the pulses. In some of the prior art there is no distinct, ramp up portion or ramp down portion. These portions are obtainable using waveform technology. The invention is equally applicable to other pulsed spray welding processes. A prior art process was accomplished by the system and graph illustrated in FIGURES 2 and 3. Conventional waveforms B1, B2 and B3 are generated together with voltage waveform C as shown in FIGURE 3. To create these waveforms, which are to be optimized as shown in FIGURE 4, the flow chart of FIGURE 2 is implemented to perform a program or routine P. Generator 70 causes a current ramp up portion as indicated by block 100. This control portion of the waveform is terminated after time T1 to create a peak current portion as indicated by block 102. This peak current portion continues until time T2 at which time block 104 is activated to ramp down the current of the welding process. At time T3, a background current indicated by block 106 is implemented until time T4. Then generator 70 is reset by timer 110 as indicated by line 110a to again start the timer to implement the waveform shown in FIGURE 4. Waveform B is schematically illustrated in FIGURE 3; however, the welding process is abruptly changed when there is a short circuit. This is illustrated as occurring at point 120. At this time, the sensed voltage is less than a reference voltage in accordance with standard technology. The

short circuit creates a signal illustrated as a signal in line 122 shown in FIGURE 2 if the short circuit occurs during the ramp down. If a short occurs in the background portion of the waveform a signal is created as illustrated in line 124. A signal in line 122 or line 124 activates the short circuit clearing circuit 130 to increase the current flowing between the electrode and workpiece. This terminates the short circuit. When the short circuit has terminated, the voltage sensed by the welder increases to a level indicated in program P to be 15 volts. When this happens, a return line 132 is activated so that circuit 130 is terminated and the normal pulse waveforms are again processed. This is standard technology and causes some instability in the welding process. Interruption of the normal pulse welding process prevents solid wires from being transferred effectively in pulsed spray welding, especially when used in the large welding environments, such as pipe welding and offshore construction. After the increased current clears the short circuit at point 120a program P represented by the block diagram in FIGURE 2 is again implemented. The heat is drastically increased to cause problems in out-of-position welding. If the prior art process is used in open root welding, the high current flow to burn off the short circuit has a tendency to also liquefy the welding metal and possibly burn through the root. Consequently, existing pulse welding procedure implemented by welder A in FIGURE 1 using program P of block diagram in FIGURE 2 has the result shown in FIGURE 3 when there is a short circuit at point 120. Using a conventional pulse program (waveform technology or otherwise), the process is not stable at lower voltages and therefore operates too hot for the root pass. The new pulse waveform is very robust at lower voltages and can put in the root pass at the necessary heat input. The present invention is an improvement to the existing short circuit processing procedure that makes the welding waveform more forgiving in the prevention of stubbing from excessive shorting events. When the electrode shorts at point 120 the present invention quickly responds to supply more heat in a short period of time without giving the electrode time to burn through or excessively melt as can result when using the prior art.--

In the specification, please delete the paragraph at page 12, line 19 through page 14, line 16 and substitute therefor the following substitute paragraph:

--The present invention is illustrated in FIGURES 5, 6 and 7 is shown using a waveform technology welder. Control network or circuit 200 includes feedback error

amplifier 202 for current and error amplifier 204 for voltage. These amplifiers compare the signals on lines 56, 66 with output lines 210, 212 respectively, from generator 70 to control the voltage level on control line 72, either in a digital format or analog form. The level of this signal controls either the voltage or current as previously explained. The pulse waveform is a current waveform best shown in FIGURE 7 with a resulting voltage waveform C similar to the voltage waveform C in FIGURE 3. Select circuit 220 selects the desired pulsed waveform B to be used by welder A. Timer 222 produces the lapsed time signals described in connection with FIGURE 4. The output 222a of timer 222 is directed to summing junction 240 to create a reset signal in line 242. This resets timer 110, as shown in FIGURE 2. A short circuit detector or sensing circuit 230 senses the existence of a short circuit, as previously used in implementing the prior art. This circuit is used in a different manner in the present invention. A short circuit sensed on line 66 and reference voltage signal on line 232 by circuit 230, which is normally a digital comparator, creates a signal in line 234 when there is a short circuit. This signal is directed to junction 240 which immediately creates a reset signal in line 242. Consequently, when using the invention, if there is a short circuit at point 120, as shown in FIGURE 7, the waveform timer is reset to immediately start a new waveform. In FIGURE 7 waveform B1 is followed by waveform B2. During the background portion of waveform B2 there is a short circuit at point 120. This immediately causes a signal in line 234 to start a new waveform B3. This new waveform rapidly clears the short circuit at point 120a and allows the welding process to continue. This procedure causes an immediate abrupt correction of the short circuit and automatically adjusts the heat according to the time spacing of point 120 from the start of the waveform. Program or routine 250 implements the present invention is shown in FIGURE 6. Blocks 100, 102, 104, 106 are essentially the same as like blocks in FIGURE 2 of the prior art program. However, in the illustrated embodiment of the present invention, a short circuit during either ramp down or during background current portion creates a signal in line 252 or 254. Both a short circuit during the ramp down of the pulse or during the background of the pulse causes a signal in line 234 as shown in FIGURE 5. This resets timer 110 to cause circuit 260, shown in FIGURE 5 as part of generator 70, to immediately start the next pulse. It has been found that immediate starting of the next pulse substantially increases the robust nature of the welding process and allows use of the pulse welding process for open root welding, as well as welding in all positions, one of which is

schematically illustrated in FIGURE 10. When using the invention, the short detector or sensor circuit 230 is implemented only during the ramp down portion and the background portion of waveform B. It is understood that the same network could be used in all portions of the waveform; however, a short circuit of the type anticipated by the present invention normally occurs during the time the pulse has melted a substantial amount of metal on the end of the electrode. The melted metal is awaiting spray or globular transfer to the workpiece. This normally does not occur at the start of the waveform or during peak current portion c. The invention can be used with welders not using waveform technology and where the pulses do not have the distinct ramp portions.--